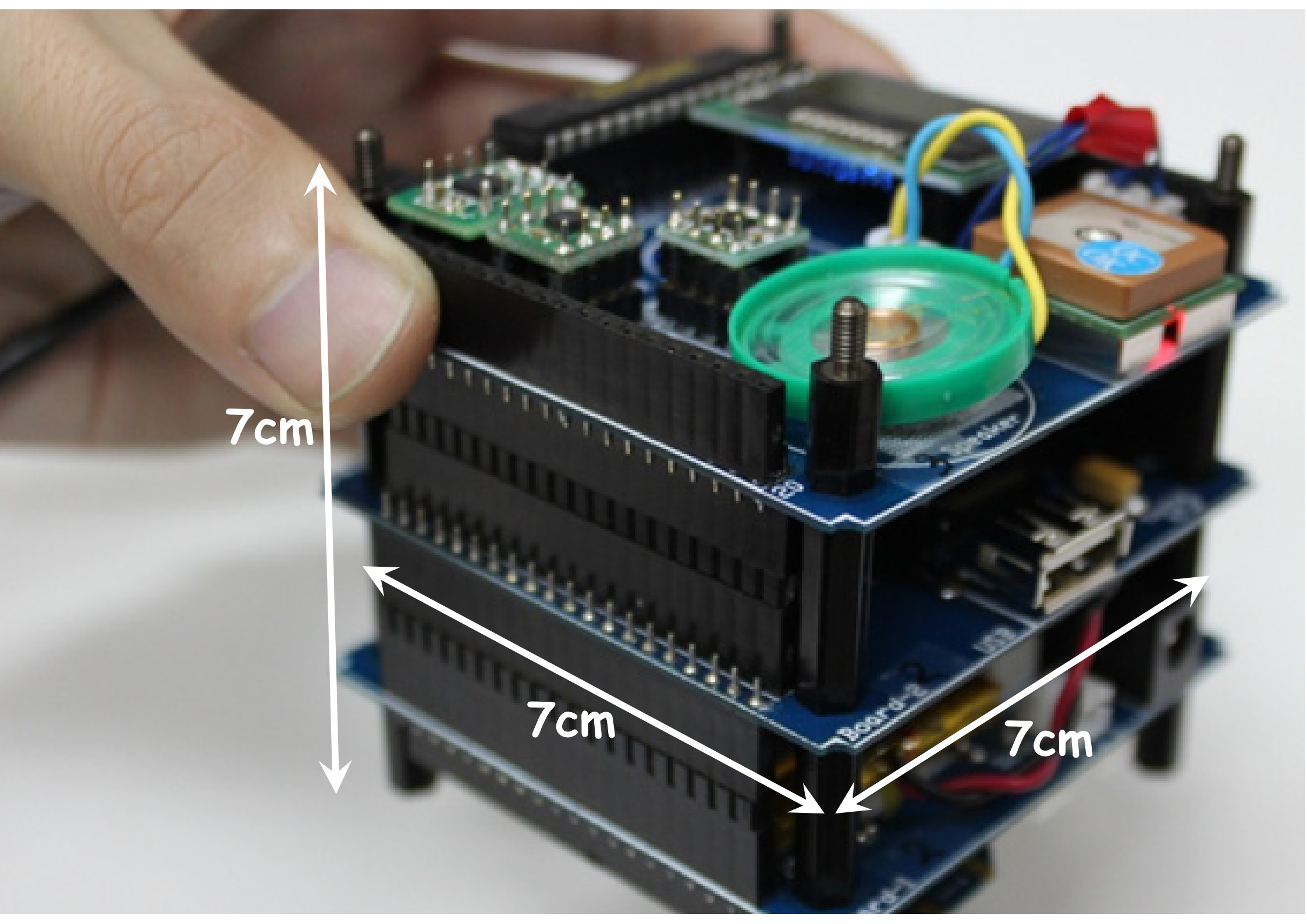
Space Systems Engineering Education by Providing Hands-on Practices Using Pico-Satellite Training Kit

Masahiko Yamazaki, Nihon University

11 Aug. 2016, Small Satellite Conference


7cm
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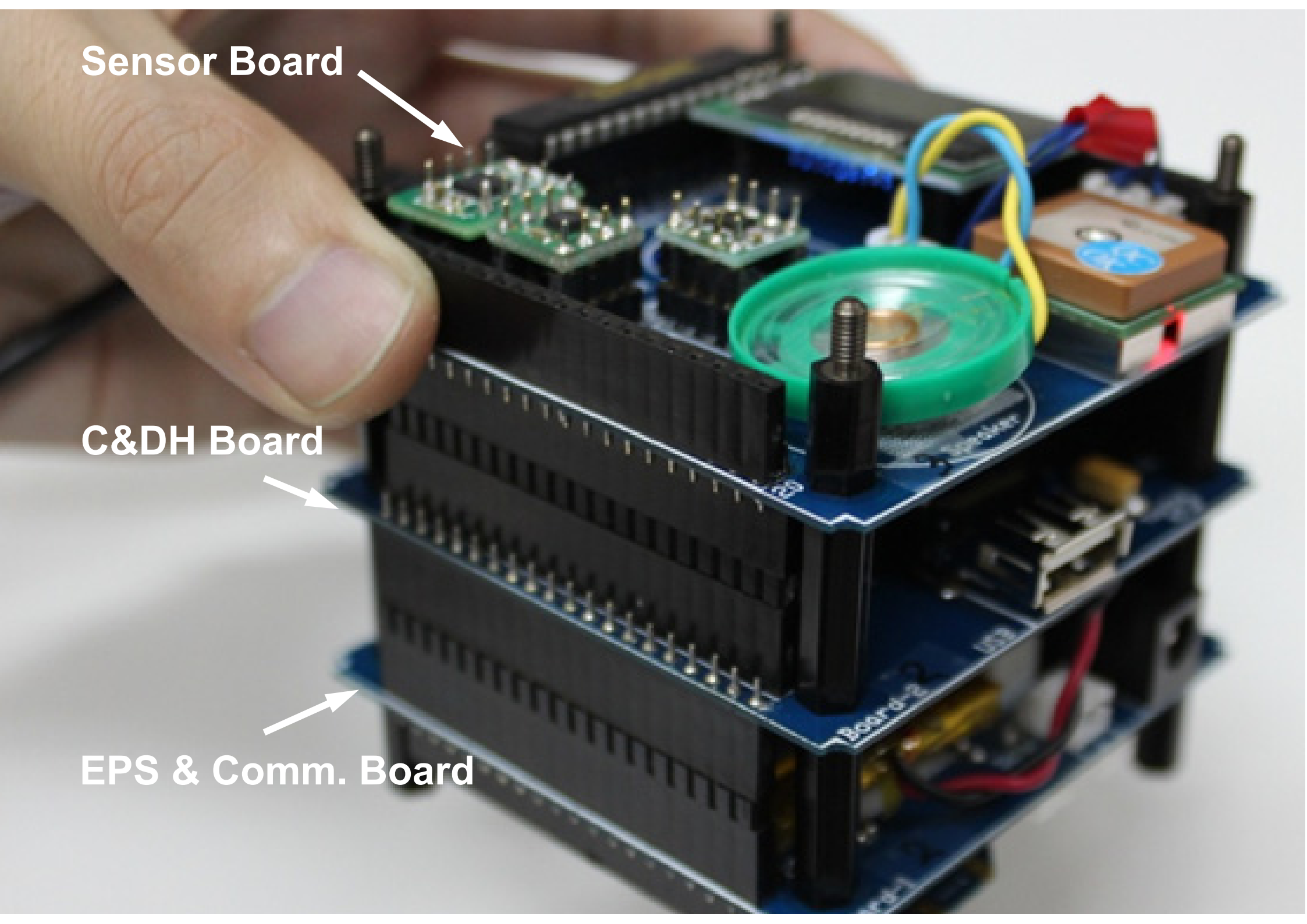
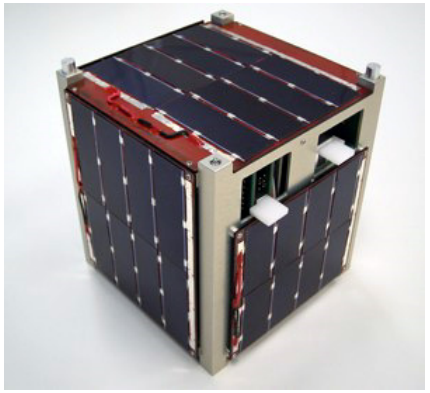
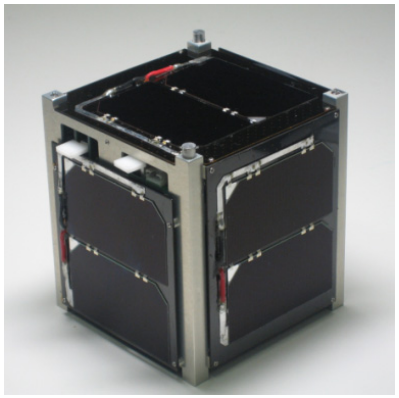

Sensor Board
C&DH Board
EPS & Comm. Board

Why Satellite?

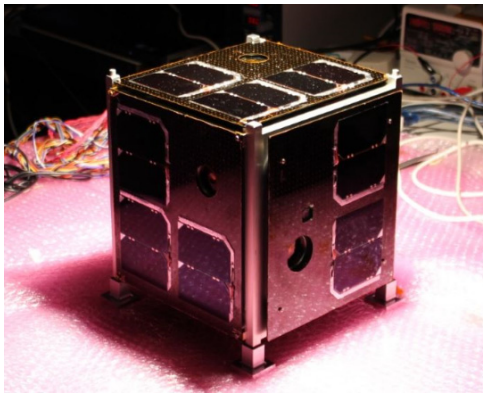
HEPTA-Sat training kit is based on former CubeSat development experience at Nihon University Space Structure Systems Laboratory.



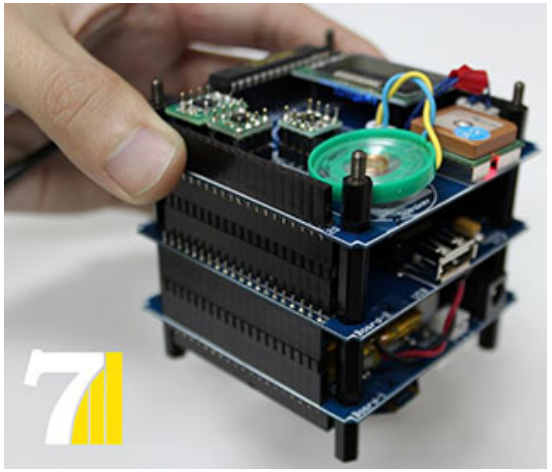
SEEDS(2006)

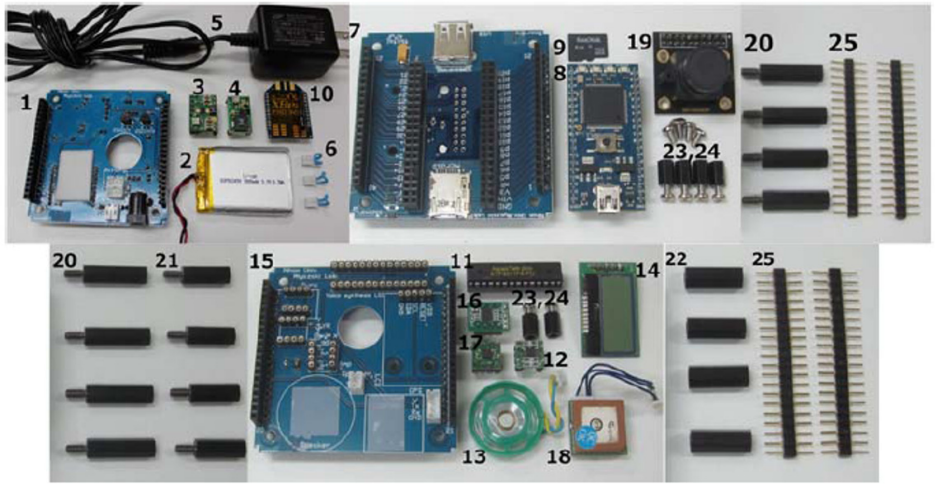


SEEDS-2(2008)



SPROUT(2014)



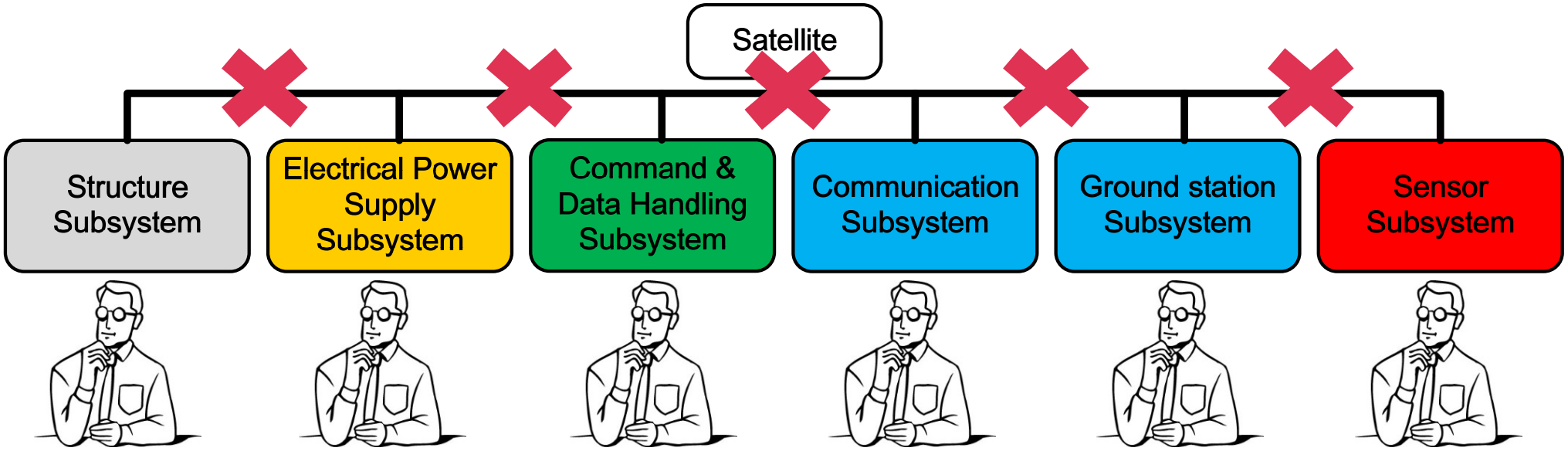


Why Satellite?

Satellite is possible to learn **variety of elemental technologies**

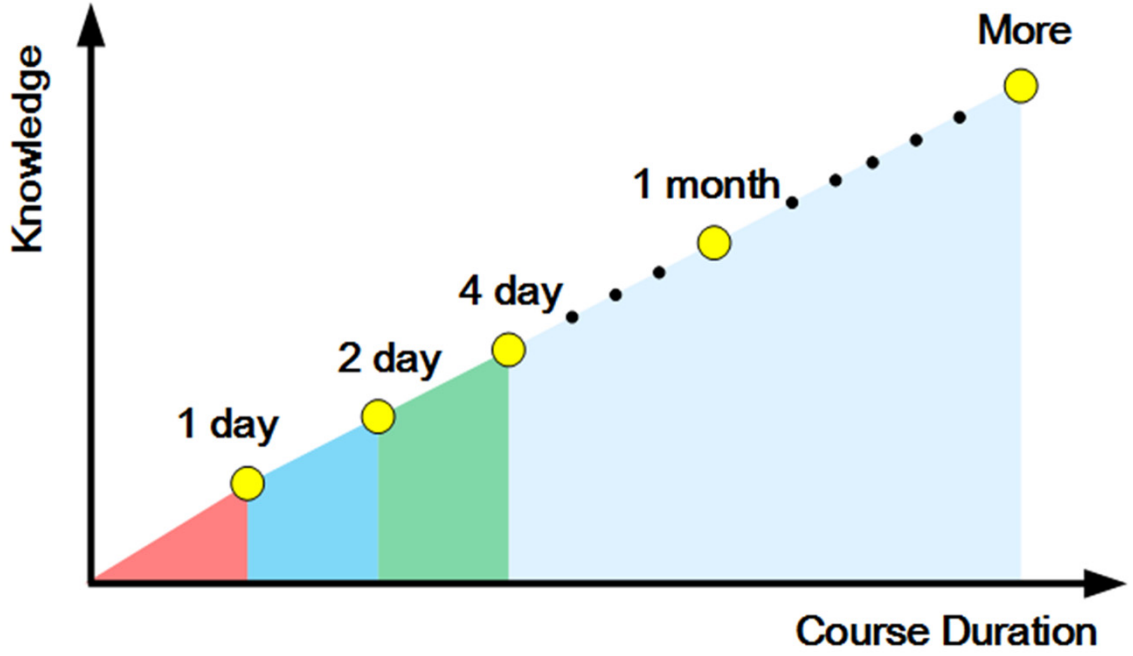
- ★ Mechanical engineering, electronic engineering and communication engineering and it's system integration.
- ★ To learn the space systems engineering, satellite project based learning is a very effective training way.

It is sometimes **hard to gain knowledge or experience** of the whole development process because the roles are divided into team members.



Concept

- ★ Effective and low-cost tool to understand space systems engineering over a short amount of time by oneself.
- ★ It can select course duration and educational style depend on the situation.
- ★ Provide learning opportunity to large number of students with varied background.



Self-education

Group-education

What is HEPTA-Sat training kit?

Concept

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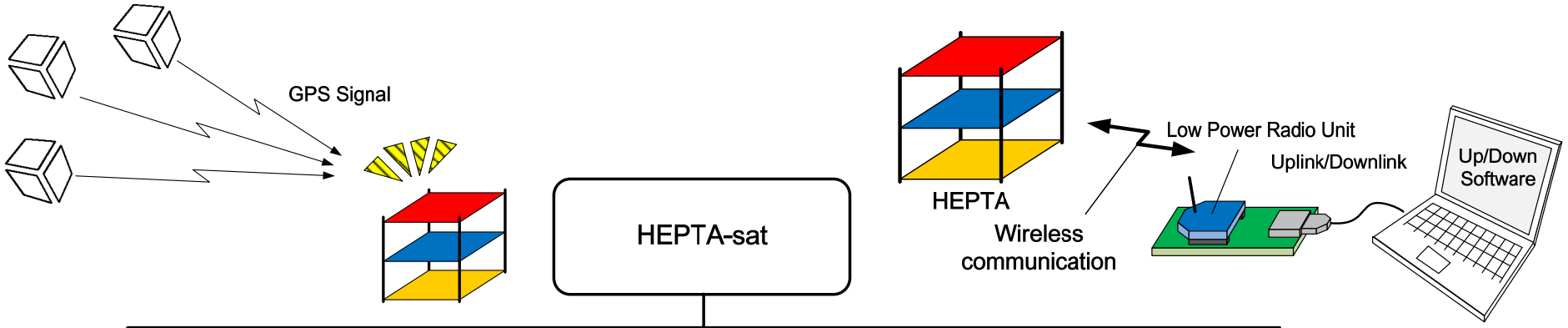
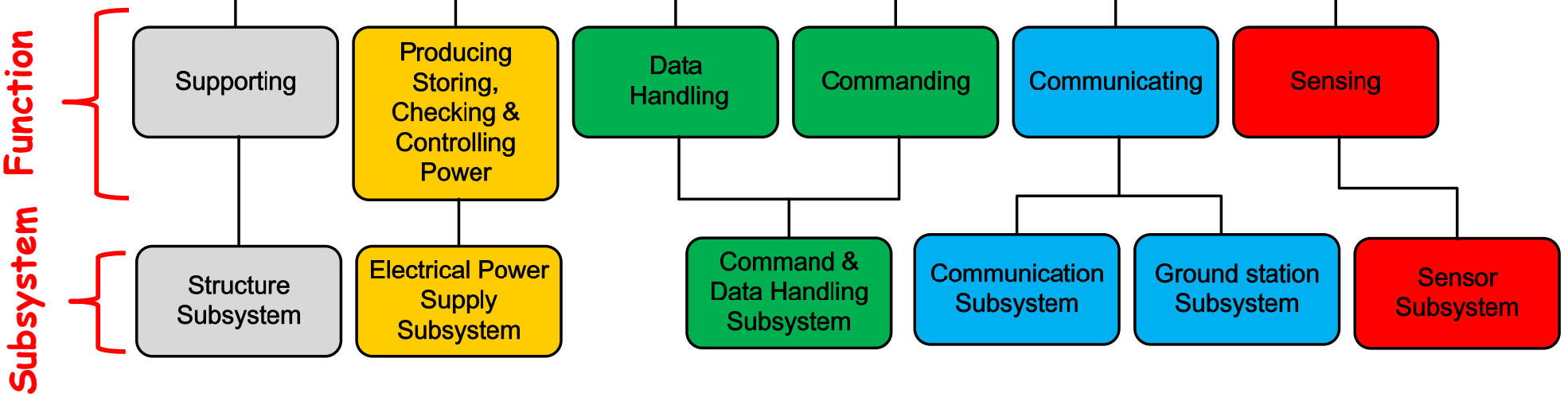
- ★ It can select course duration and educational style depend on the situation.
- ★ Provide learning opportunity to large number of students with varied background.

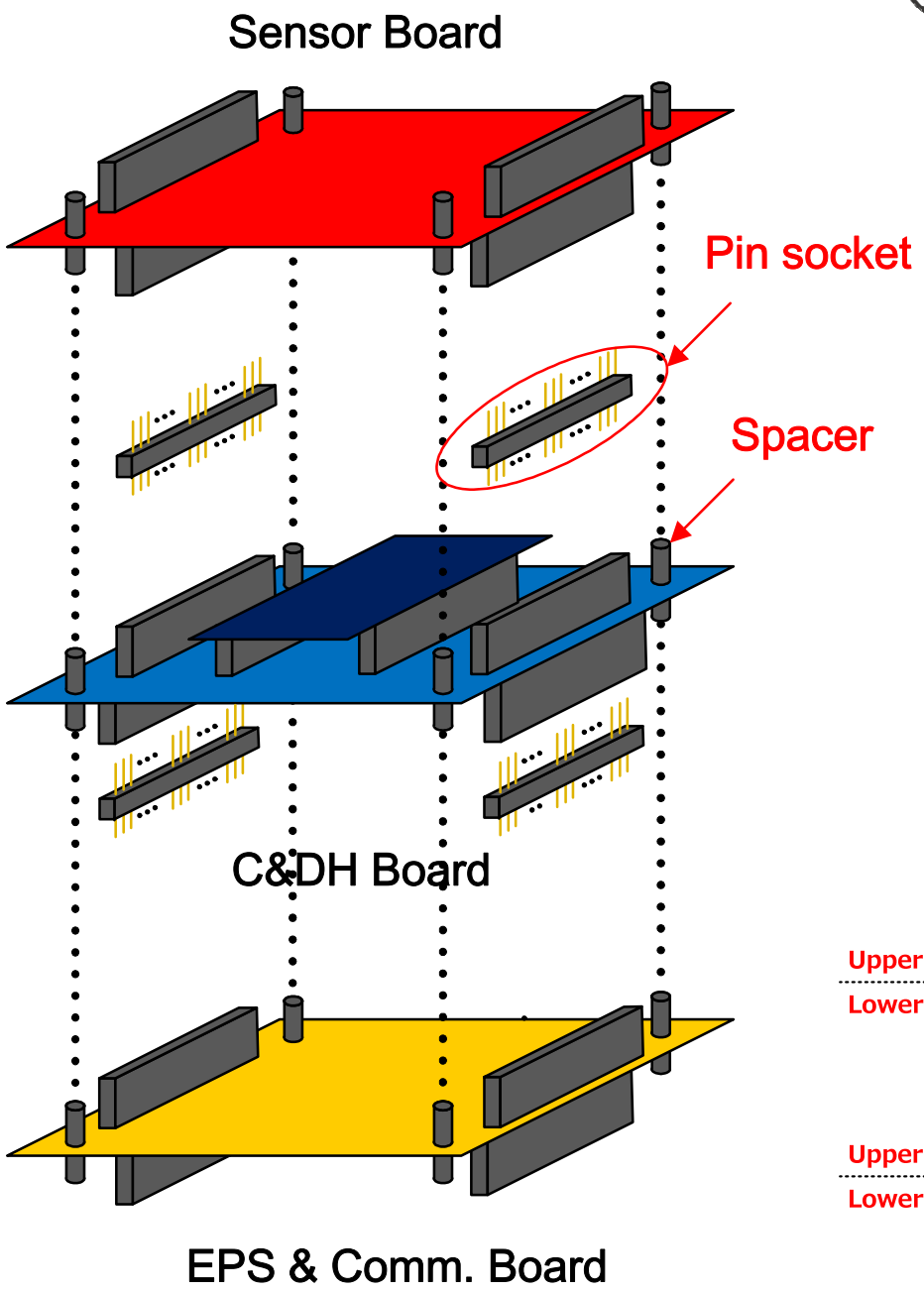
What is HEPTA-Sat training kit?

Composed of 6 function and 6 primary sub-systems. You can learn **how each subsystem functions** and **how to integrate subsystems into a satellite** through experiencing the process of assembly, integration including programing & system implementation and test.





What is HEPTA-Sat training kit?



Pin socket

Electrically connected through pin-sockets. Every board has same electrical interface.

Spacer

Physically connected and fixed with spacer.

Electrical Interface

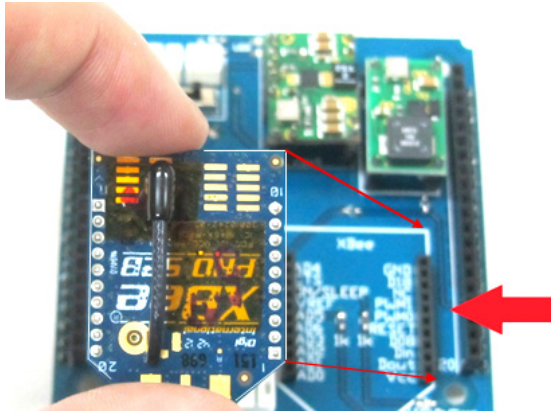
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Upper Surface	GND	VIN	VB	nR	I/O	I/O	I/O	I/O	tx	rx	mosi	miso	sck	rx	I/O	ADC	I/O	I/O	I/O	I/O
Lower Surface	GND	VIN	VB	nR	I/O	I/O	I/O	I/O	tx	rx	mosi	miso	sck	rx	I/O	ADC	I/O	I/O	I/O	I/O

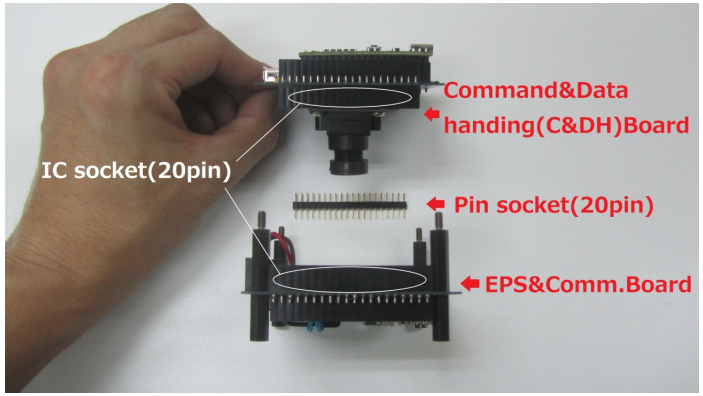
	40	39	38	37	36	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21
Upper Surface	VOut	VU	IF−	IF+	RD−	RD+	TD−	TD+	D−	D+	I/O	I/O	sda	scl	I/O	I/O	I/O	I/O	I/O	I/O
Lower Surface	VOut	VU	IF−	IF+	RD−	RD+	TD−	TD+	D−	D+	I/O	I/O	sda	scl	I/O	I/O	I/O	I/O	I/O	I/O

What is HEPTA-Sat training kit?

Characteristics

- Almost all major onboard equipment is removable and can be assembled and integrated repeatedly.
- It is possible to easily add or change the experiment module. Users can design, manufacture and integrate their own circuit board to run an original mission.
- It can be used either alone or by team.
- The textbook allows beginners (such as junior high to university students) to study the software, hardware, and ultra-small satellites efficiently and systematically on their own.



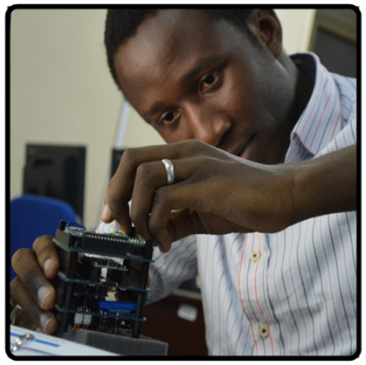


Course Goal

Experiencing the development process of ultra-small satellites in a short time and acquiring the basic knowledge of space engineering.

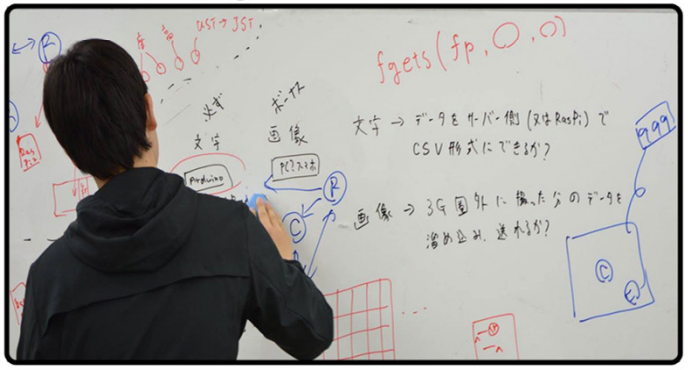
Step 1:
Lecture

Step 2:
Hardware Assembly



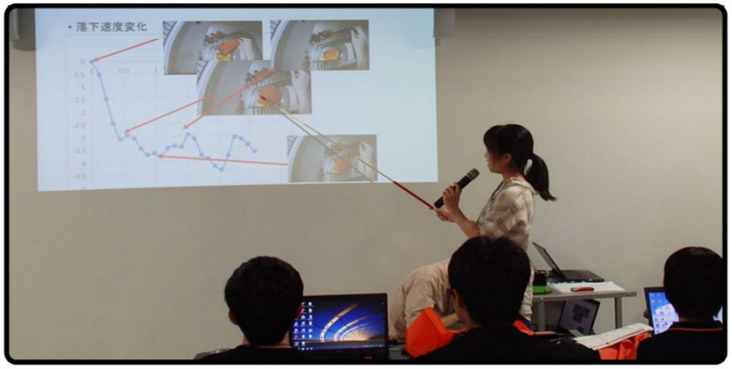
Step 3:
Hardware & Software Integration

Step 4:
Mission Design



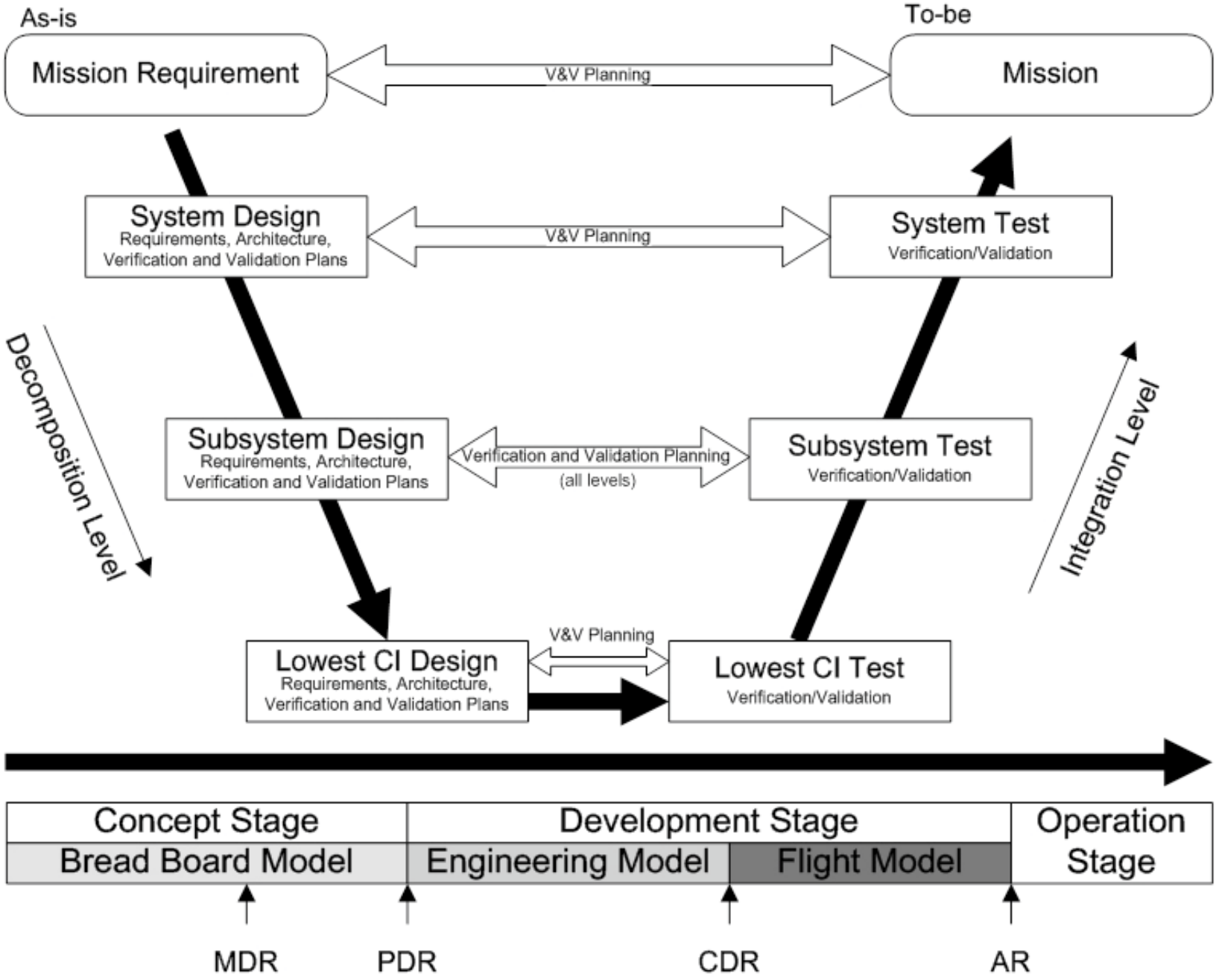
Step 5:
Field test

Step 6:
Review & Presentation

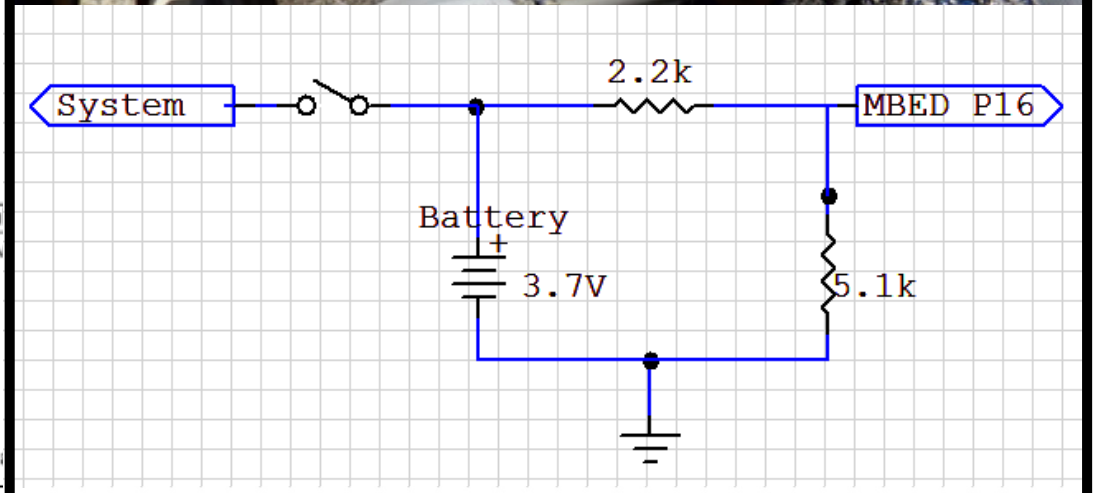


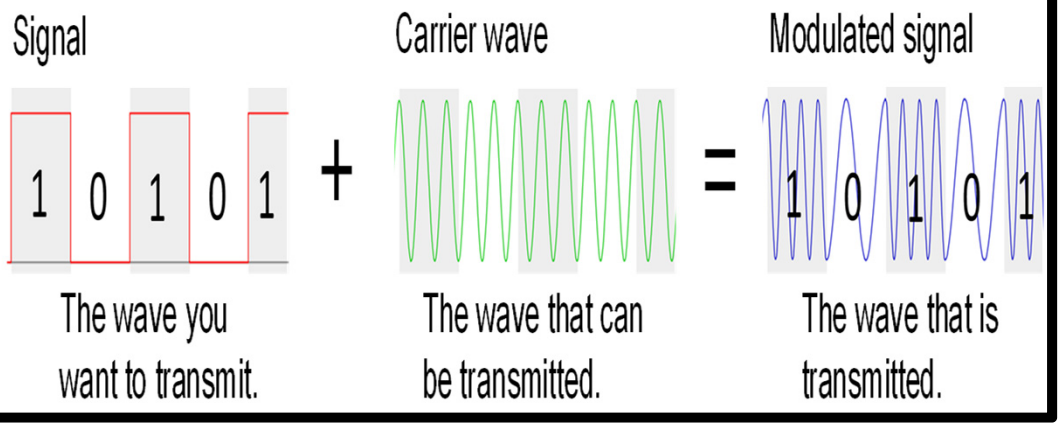
Congratulations!

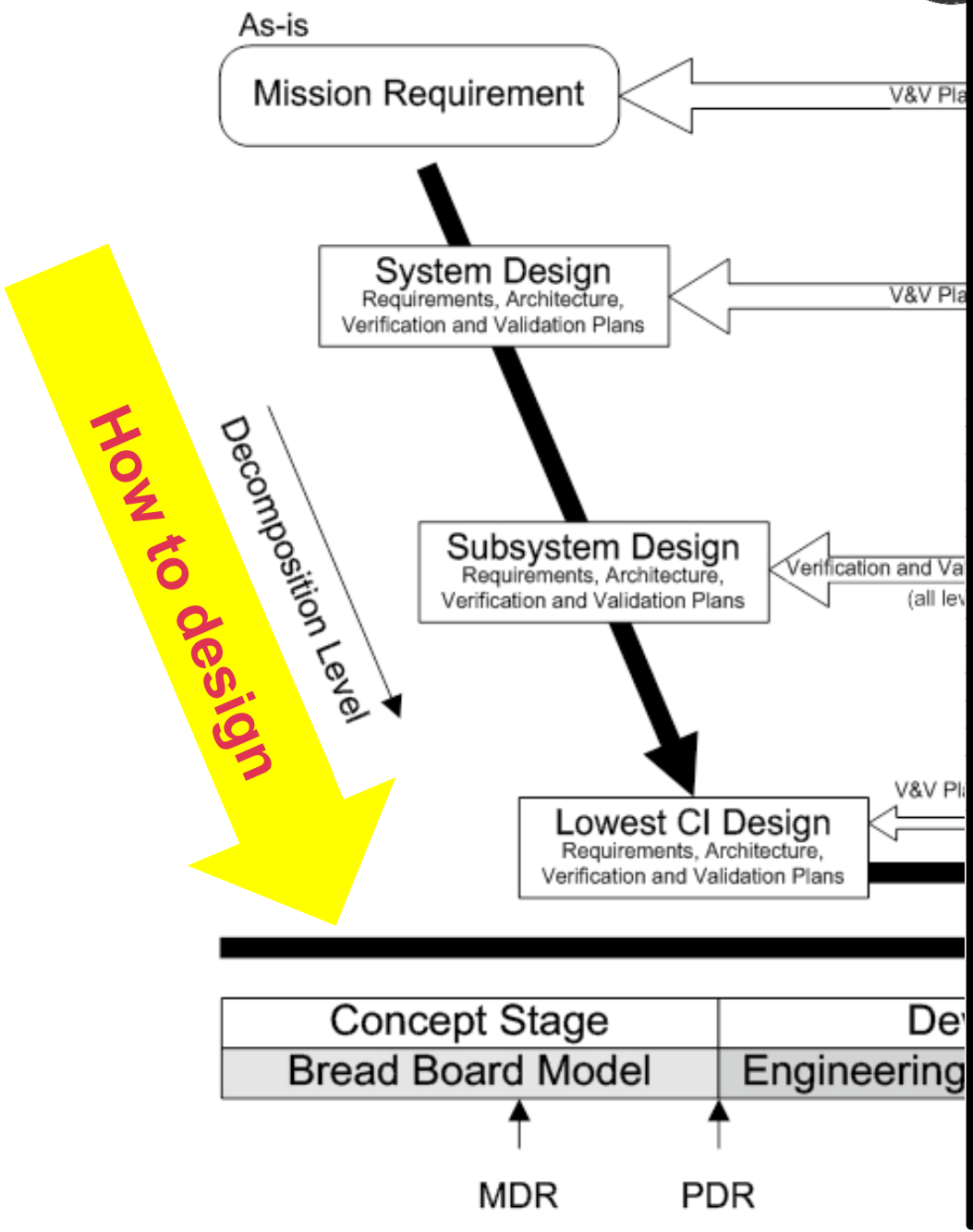
Course Overview



Course Overview







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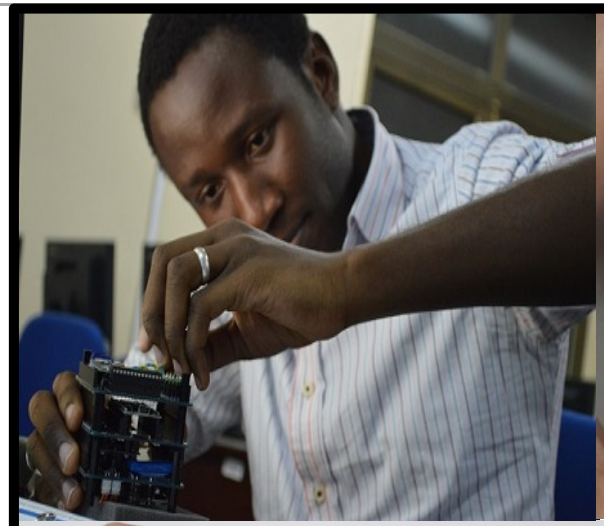
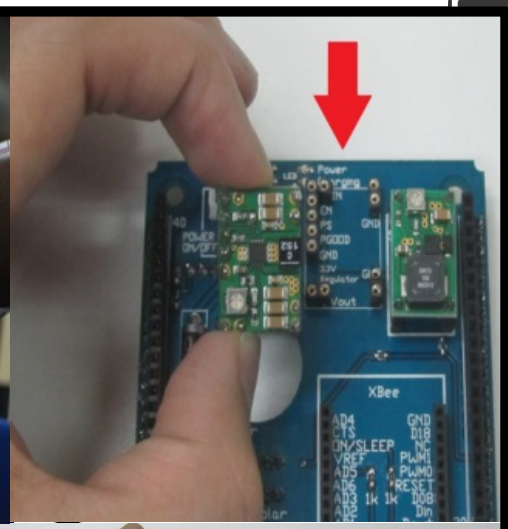
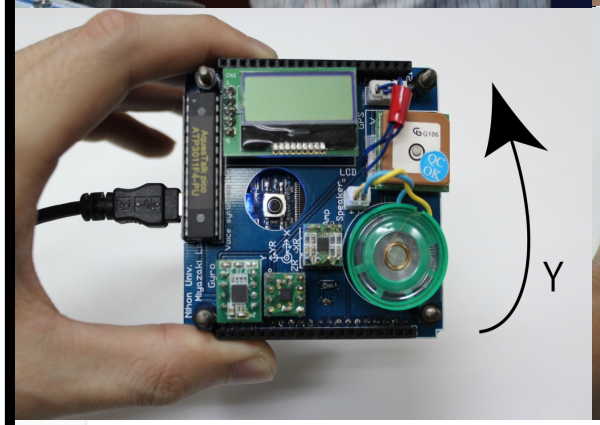
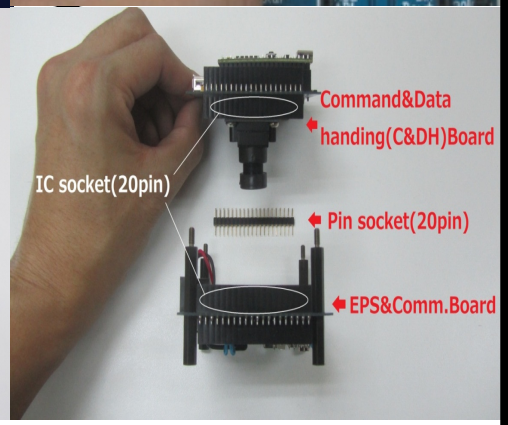
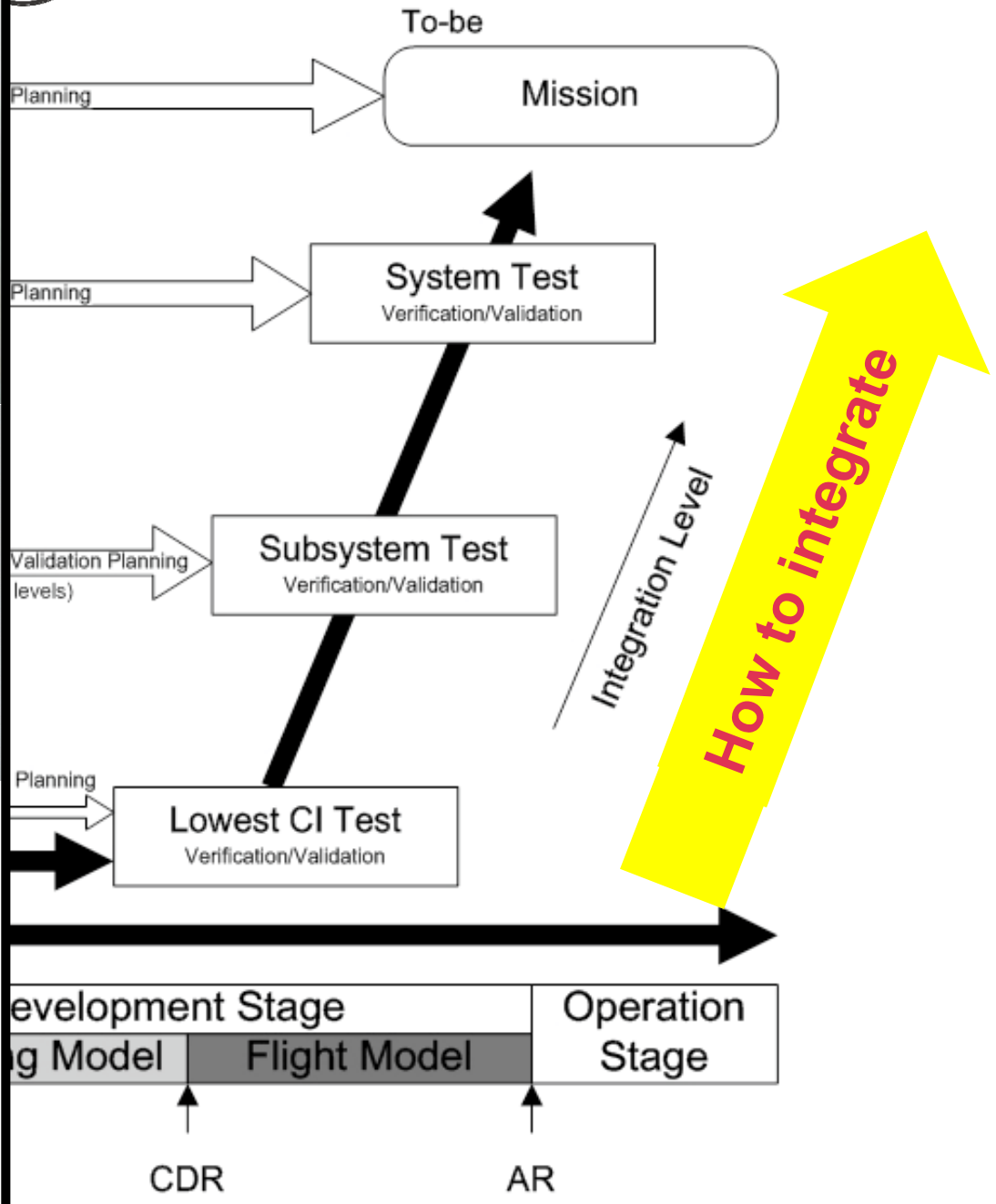








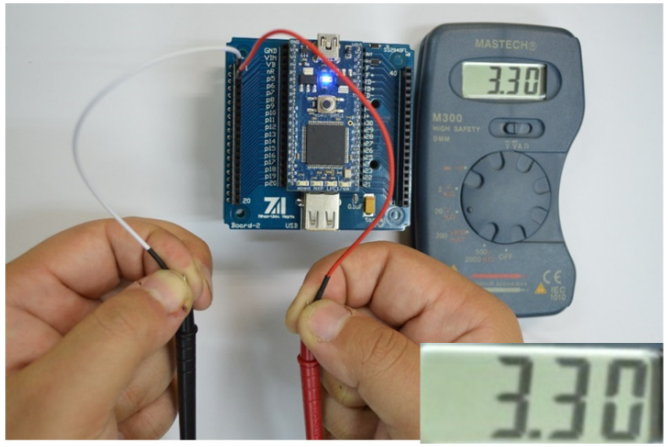

```
28 int main() {
29     pc.baud(9600);
30     gps.baud(9600);
31     xbee.baud(9600);
32     mkdir("/sd/mydir", 0777);
33     FILE *fp = fopen("/sd/mydir/sdtest.txt", "w");
34
35     while(1){
```



Course Goal

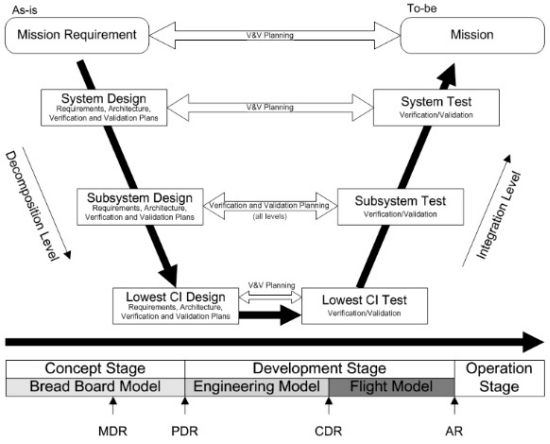
Experiencing the development process of ultra-small satellites in a short time and acquiring the basic knowledge of space engineering.

- ★ Learn operations of the each physical components through assembly and integration.
- ★ Learn basic programming skills to make satellite software and ground station software.
- ★ Learn the Verification & Validation way of physical components and integrated system.



main.cpp

```
1  #include "mbed.h"
2  #include "HeptaBattery.h"
3  #include "SDFileSystem.h"
4  #include "HeptaVoice.h"
5  #include "HeptaLcd.h"
6  #include "HeptaAccel.h"
7  #include "HeptaGyro.h"
8  #include "HeptaGPS.h"
9  #include "HeptaCamera.h"
10 #include "HeptaXbee.h"
11 Serial pc(USBTX,USBRX);
12 DigitalOut myleds[] = {LED1, LED2, LED3, LED4};
13 HeptaBattery battery(p16,p29,p26);
```



Recent Workshops

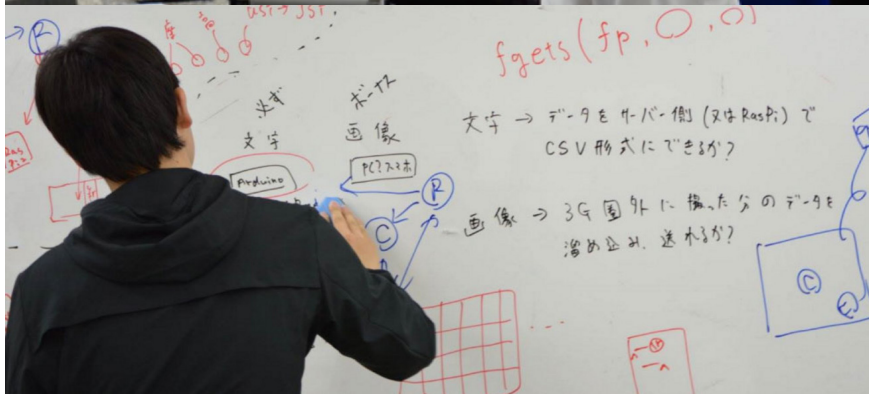
Day: 17-21, Mar., 2015
Course duration: 5day
Student: Engineer
Staff: 1 instructor and 2 assistant students
Site: All Nations University College @ Ghana

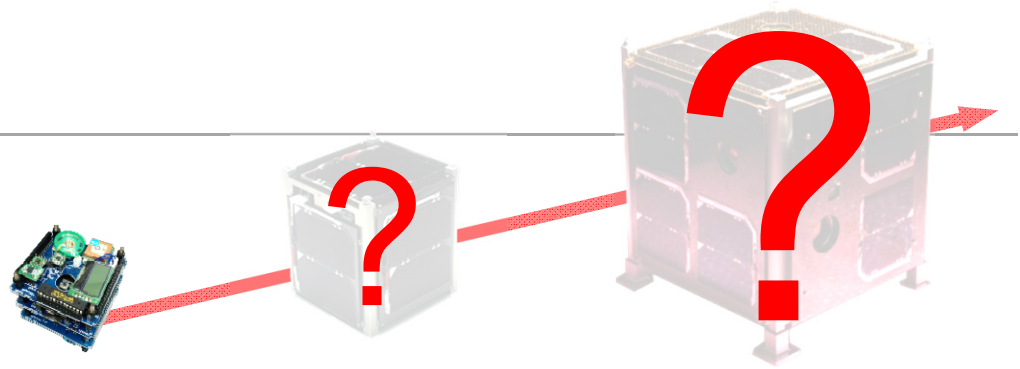
Day: 31, Oct. – 3, Nov., 2015
Course duration: 4day
Student: Engineer
Staff: 1 instructor and 2 assistant students
Site: Nihon University @ Japan

Day: 17, April - XXX, 2016
Course duration: for a year
Student: junior high school and high school students
Staff: 1 instructor and 2 assistant students
Site: Science Museum @ Japan

Day: 1-4 , Aug., 2016
Course duration: 4day
Student: industrial high school students
Staff: 1 instructor and 2 assistant students
Site: Nihon University @ Japan

Day: 3-5, May., 2016
Course duration: 3day
Student: higher professional school students
Staff: 1 instructor and 1 assistant student
Site: higher professional school @ Japan





Conclusion

- The low cost of implementation, short preparation time and simplicity of design make excellent practical opportunity for students to take their first steps in space engineering.
- Although the development of CanSat and ultra-small satellites is a small-scale project, the project is divided into respective tasks and member, which tends to essentially limit the overall knowledge and experiences.
- This training kit work effectively as one for bridging such a gap to handle the overall system in the individual level before starting the actual project.
- These learning experiences can create opportunities for in-depth study of the significance, mission plan, specialized theory, design, development, experiment, and later evaluation of satellites.

Acknowledgement

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Contact

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